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CALCULATION OF ELECTROMAGNETIC FIELD IN NEAR FIELD ZONE OF REFLECTOR ANTENNA WHITH EDGE RADAR ABSORBING COATING

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ABSTRACT

In the paper technique of electromagnetic field calculation in near-field zone of parabolic antenna with reflector edges covered by toroidal radar absorbing coating is presented. The calculation technique is based on the applying of the integral representations obtained using Lorentz lemma. For calculation of the reflector edge parts contribution to the total antenna field the solution of model scattering problem for half-plane with radar absorbing cylinder on the edge, sounded by plane electromagnetic wave, is used. Calculation results for different values of radius of radar absorbing coatings are presented.

INTRODUCTION

In a number of situations the radar systems antennas may be positioned nearly one to another. In this connection the problem of electromagnetic compatibility and interference immunity of such systems is of importance. One way of improvement of antennas interference immunity in back half-space is the reflector edge coating by radar absorbing materials. Therefore the problem of calculation of electromagnetic field in near-field zone of antennas with radar absorbing coating on the edges is of interest.

THE TECHNIQUE OF SOLUTION

The parabolic-reflector antenna with reflector edges covered by toroidal radar absorbing coating is located in the free space (Fig. 1). Let's consider a case, when the antenna feed is the pyramidal horn located in antenna focal point.
Near the reflector surface antenna feed creates the following field:

$$\vec{E}^{i}\left(\vec{X}\right)=\frac{jk_0}{4\pi}\,\vec{p}'\,\frac{exp\left[jk_0\vec{R}^0\left(\vec{X}+\vec{\rho}\right)\right]}{\vec{R}^0\left(\vec{X}+\vec{\rho}\right)}F(\theta,\varphi). \qquad (1)$$

Here, according to Fig. 1 $\vec{R}^0$ is unit vector sounding direction from antenna feed to the point A on the reflector surface, the angel θ characterizes a direction of a vector $\vec{R}^0$ concerning an antenna axis, and angel φ characterizes position of the point A with reference to the plane xOz, $\vec{\rho}$ is the radius-vector, directed from the focal point to vertex of reflector, $\vec{p}'=\dfrac{\vec{R}^0\times\left(\vec{p}\times\vec{R}^0\right)}{\left|\vec{R}^0\times\left(\vec{p}\times\vec{R}^0\right)\right|}$ is the polarization of wave incident in direction $\vec{R}^0$ ($\vec{p}$ is the vector antenna feed polarization), μ_0, ε_0 are permeability and permittivity of free space, $k_0 = \omega\sqrt{\varepsilon_0\mu_0}$. The function $F(\theta,\varphi)$ defines dependence of antenna feed field amplitude and phase in a far-field zone for angular coordinates θ and φ.

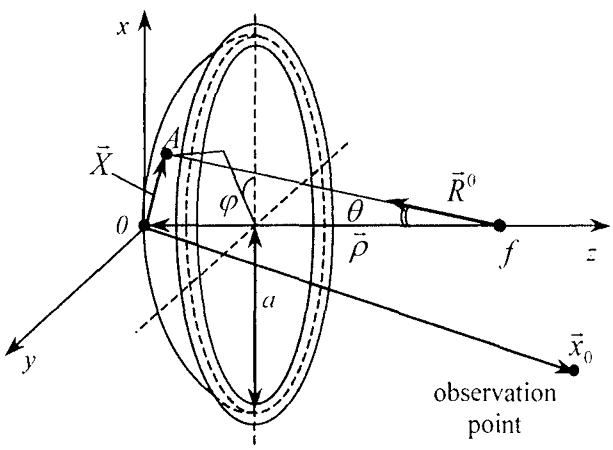

Fig.1

The field of the antenna in observation point can be represented as the sum of the feed field $\vec E^{i}(\vec x_0)$ and field scattered by antenna reflector $\vec E^{s}(\vec x_0)$:

$$\vec E(\vec x_0) = \vec E^{i}(\vec x_0) + \vec E^{s}(\vec x_0). \quad (2)$$

As a main calculation formula for determination of scattered by reflector field we shall use an integral representation of a field obtained using Lorentz lemma

$$\vec p\vec E^{s}(\vec x_0) = \frac{1}{4\pi}\int_S \frac{e^{jk_0 r}}{r}\sqrt{\frac{\mu_0}{\varepsilon_0}}\left(\frac{2-2jk_0 r}{jk_0 r^2}\vec p^{\parallel} + \left(\frac{jk_0 r - 1}{jk_0 r^2} - jk_0\right)\vec p^{\perp}\right)\vec H^{\perp}ds + \frac{1}{4\pi}\int_S \frac{e^{jk_0 r}}{r}\left(\frac{1-jk_0 r}{r}\right)\vec p\left(\vec r_0\times\vec E^{\perp}\right)ds, \quad (3)$$

where S is arbitrary closed surface which encloses the antenna reflector. $\vec E^{\perp} = \vec n\times\vec E$, $\vec H^{\perp} = \vec n\times\vec H$, $\vec n$ is the internal normal unit vector. $\vec p$ is the receiver polarization, $\vec r_0$ is the unit vector of the direction from a point on the surface S to the observation point, $\vec p^{\parallel} = (\vec p\cdot\vec r_0)\vec r_0$, $\vec p^{\perp} = \vec p - (\vec p\cdot\vec r_0)\vec r_0$, r is the distance between the point on the surface S and the observation point. Let's select the surface of integration as a surface coinciding with reflector surface everywhere except the some neighborhood of the edge. Then the integral in (3) (we shall denote it as $I(\vec x_0)$) it is possible to represent as the sum of integrals on the reflector surface S_1, not including a neighbourhood edge, and surface S_0, enclosing edge neighborhood

$$I(\vec x_0) = I_{S_1}(\vec x_0) + I_{S_0}(\vec x_0). \quad (4)$$

$I_{S_1}(\vec x_0)$ we shall calculate using the solution of the model scattering problem for half-plane with radar absorbing cylinder on the edge, sounded by plane electromagnetic wave [1]. Since the electrical sizes of the antenna reflector are great, the contribution of the surface S_1 in total field we shall carry out in Kirchhoff approximation.

RESULTS OF NUMERICAL CALCULATION

Using described technique the calculations were carry out for a case when $k_0 a = 30$ (a is aperture reflector radius), $k_0 f = 26$ (f is the reflector focus distance), the feed created distribution of field amplitude reducing to antenna edge on 15 dB, the observation point located on the plane yOz, the absorber is made of the material with relative electrical parameters $\mu = 1.35 + j0.8$ and $\varepsilon = 20 + j0.1$. In figures 2 and 3 the dependences of normalized amplitude of antenna field from the angle ψ between a direction of observation point and axis Oz are presented. Distance from the origin of coordinate system to the observation point was 17λ (λ is the wavelength). The figure 2 corresponds to the case, when the vector of feed polarization is parallel to axis Ox, in the figure 3 the feed polarization vector is parallel to axes Oy. In figures 2 and 3 bold solid lines correspond to a case, when the absorber on the edge is absent, a thin solid line corresponds to a case when the absorber radius is equal to 0.2λ, dashed line corresponds to the case when the absorber radius is equal to 0.4λ.

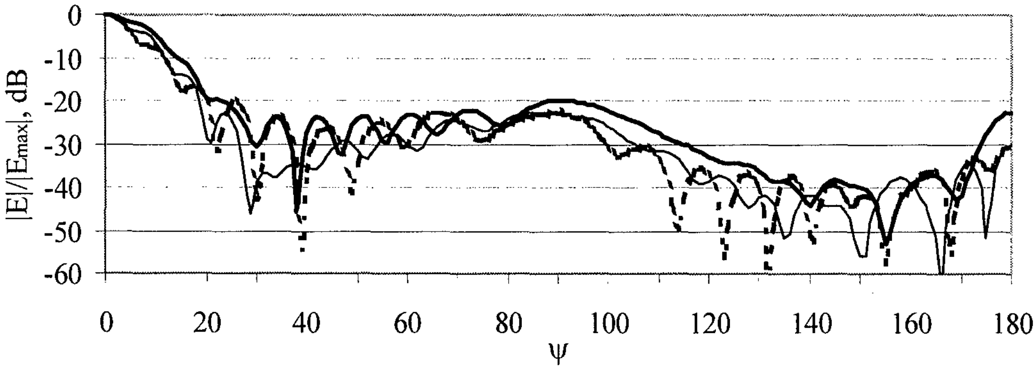

Fig. 2

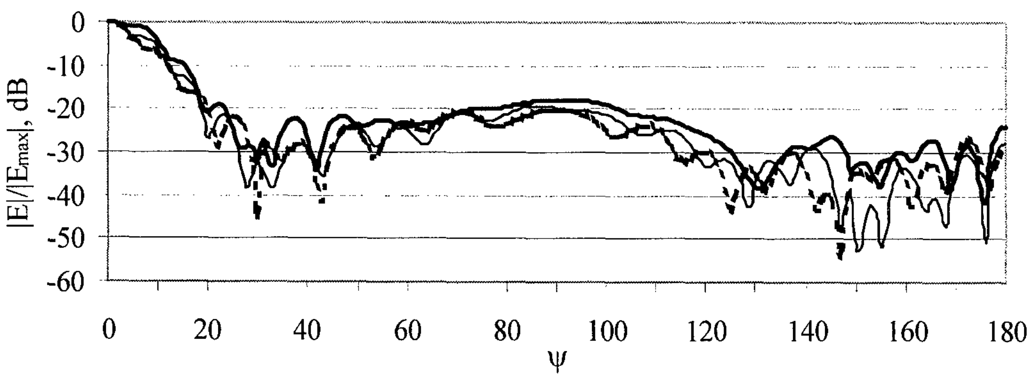

Fig. 3

The analysis of simulation results has shown, that the using of the absorber with radii 0.2λ and 0.4λ reduces the antenna radiation at $\psi = 177^0..180^0$ at the average on 7 dB. For different polarizations the value of lowering antenna lateral radiation is also different. So for $\psi = 140^0..170^0$ at the figure 3 we can see rather strong radiation reduction for the antenna with radius absorber equal to 0.2λ.

It is necessary to denote that choosing of absorber parameters should be carried out for each specified construction of antenna.

REFERENCES

[1]. Y.K. Sirenko, I.V. Sukharevsky, O.I. Sukharevsky, and N.P. Yashina.
Ed. by Y.K. Sirenko. Fundamental and applied problems of the electromagnetic wave scattering theory. -Kharkiv: Krok, 2000. (In Russian).